

I claim:

1. An apparatus for curing an article passing through said apparatus through ultraviolet irradiation, comprising:

a hollow tubular ultraviolet light emitting device having an interior surface and an exterior surface;

5 an ultraviolet transparent tubular element defining a first space for insertion of an article to be cured, said tubular element being surrounded by said ultraviolet light emitting device defining a second space between an interior surface of said light emitting device and an outermost surface of said tubular element; and

10 means for passing an inert gas through said first space.

2. The apparatus according to claim 1, wherein the tubular ultraviolet light emitting device is cylindrical.

- 15 3. The apparatus according to claim 1, wherein the tubular element is removably connected to be easily removed and replaced.

4. The apparatus according to claim 1, further comprising a means to heat the inert gas passing through said first space.

- 20 5. The apparatus according to claim 1, further comprising a means to cool the inert gas passing through said first space.

6. The apparatus according to claim 1, further comprising a means to heat or cool the inert gas passing through said first space.

5 7. The apparatus according to claim 1, wherein a surface of said tubular element is coated with a first shielding layer, said first shielding layer being substantially transparent to ultraviolet light and reflective of infrared light emitted from said tubular ultraviolet light emitting device.

10 8. The apparatus according to claim 1, wherein the interior surface of said tubular ultraviolet light emitting device is coated with a shielding layer, said shielding layer being substantially transparent to ultraviolet light and reflective of infrared light emitted from said tubular ultraviolet light emitting device.

15 9. The apparatus according to claim 1, further comprising a dichroic reflector surrounding the exterior surface of said tubular ultraviolet light emitting device, said dichroic reflector reflecting ultraviolet light emitted from said tubular ultraviolet light emitting device.

20 10. The apparatus according to claim 1, further comprising a means for flowing a first cooling medium through said second space.

11. The apparatus according to claim 10, wherein said first cooling medium is transparent to ultraviolet radiation.

12. The apparatus according to claim 10, wherein said first cooling medium is a gas.

5 13. The apparatus according to claim 10, wherein said first cooling medium is a liquid.

10 14. The apparatus according to claim 1, further comprising a means to flow a second cooling medium past the exterior surface of said tubular ultraviolet light emitting device.

15. The apparatus according to claim 9, further comprising a means to flow a second cooling medium past an exterior surface of said dichroic reflector.

15 16. The apparatus according to claim 15, wherein said dichroic reflector has a plurality of apertures for allowing said second cooling medium to contact the exterior surface of said tubular ultraviolet light emitting device.

20 17. The apparatus according to claim 14, wherein said second cooling medium is air.

18. The apparatus according to claim 9, further comprising a third space defined between said dichroic reflector and said tubular ultraviolet light emitting device.

19. The apparatus according to claim 18, further comprising a means for passing a second cooling medium through said third space.

5 20. The apparatus according to claim 19, wherein said second cooling medium is a liquid.

10 21. The apparatus according to claim 9, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the surface of an article to be cured prior to said article entering said tubular ultraviolet light emitting device.

15 22. The apparatus according to claim 9, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the surface of an article to be cured after said article exits said tubular ultraviolet light emitting device.

20 23. The apparatus according to claim 9, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the surface of an article to be cured prior to said article entering said tubular ultraviolet

light emitting device and after said article exits said tubular ultraviolet light emitting device.

24. An apparatus for curing an article inserted in said apparatus through ultraviolet 5 irradiation comprising:

a hollow tubular ultraviolet light emitting device having an interior surface and an exterior surface;

a dichroic reflector surrounding said light emitting device, said dichroic reflector reflecting only ultraviolet light;

10 an ultraviolet transparent tubular element defining a first space for insertion of an article to be cured, said tubular element being surrounded by said ultraviolet light emitting device with a second space provided between the interior surface of said ultraviolet light emitting device and said tubular element.

15 25. The apparatus according to claim 24, further comprising a means for passing an inert gas through said first space.

26. The apparatus according to claim 25, further comprising a means to cool or heat said inert gas passing through said first space.

20 27. The apparatus according to claim 24, wherein a surface of said tubular element is coated with a first shielding layer, said first shielding layer being substantially

transparent to ultraviolet light and reflective of infrared light emitted from said tubular ultraviolet light emitting device.

28. The apparatus according to claim 24, wherein the interior surface of said tubular ultraviolet light emitting device is coated with a shielding layer, said shielding layer being substantially transparent to ultraviolet light and reflective of infrared light emitted from said tubular ultraviolet light emitting device.

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29. The apparatus according to claim 24, wherein the tubular element is removably connected so as to be easily removed and replaced.

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30. The apparatus according to claim 24, further comprising a means for flowing a first cooling medium through said second space.

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31. The apparatus according to claim 30, wherein said first cooling medium is transparent to ultraviolet radiation.

32. The apparatus according to claim 30, wherein said first cooling medium is a gas.

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33. The apparatus according to claim 30, wherein said first cooling medium is a liquid.

34. The apparatus according to claim 24, further comprising a means to flow a second cooling medium past an exterior surface of said dichroic reflector.

5 35. The apparatus according to claim 34, wherein said dichroic reflector has a plurality of apertures for allowing said second cooling medium to contact the exterior surface of said tubular ultraviolet light emitting device.

10 36. The apparatus according to claim 34, wherein said second cooling medium is air.

37. The apparatus according to claim 24, further comprising a third space defined between said dichroic reflector and said tubular ultraviolet light emitting device.

15 38. The apparatus according to claim 37, further comprising a means for passing a second cooling medium through said third space.

39. The apparatus according to claim 38, wherein said second cooling medium is a liquid.

20 40. The apparatus according to claim 24, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the

surface of an article to be cured prior to said article entering said tubular ultraviolet light emitting device.

41. The apparatus according to claim 24, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the surface of an article to be cured after said article exits said tubular ultraviolet light emitting device.

10 42. The apparatus according to claim 24, wherein said dichroic reflector reflects at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device such that said some ultraviolet radiation contacts the surface of an article to be cured prior to said article entering said tubular ultraviolet light emitting device and after said article exits said tubular ultraviolet light emitting device.

15 43. A method for curing an article passing through a curing apparatus with ultraviolet radiation, comprising:

20 passing an article to be cured through a first space defined by an ultraviolet transparent tubular element;

flowing an inert gas through said first space;

emitting ultraviolet light from a hollow tubular ultraviolet light emitting device having an interior surface and an exterior surface, said tubular ultraviolet light

device surrounds said tubular element defining a second space between the interior surface of said ultraviolet light emitting device and an outermost surface of said tubular element;

exposing said article to be cured to said ultraviolet light; and

5 flowing a first cooling medium through said second space.

44. The method according to claim 43, further comprising cooling or heating said inert gas flowing through said first space.

10 45. The method according to claim 43, wherein said first cooling medium is an ultraviolet transparent gas or liquid.

46. The method according to claim 43, further comprising cooling said first cooling medium flowing through said second space.

15 47. The method according to claim 43, further comprising flowing a second cooling medium past the exterior surface of said ultraviolet light emitting device.

20 48. The method according to claim 43, further comprising reflecting infrared radiation emitted from said tubular ultraviolet light emitting device off of a surface of said tubular element.

49. The method according to claim 43, further comprising reflecting infrared radiation emitted from said tubular ultraviolet light emitting device off of the interior surface of said ultraviolet light emitting device.

5 50. The method according to claim 43, further comprising reflecting ultraviolet radiation off of a dichroic reflector surrounding the exterior surface of said ultraviolet light emitting device.

10 51. The method according to claim 50, further comprising flowing a second cooling medium over an exterior surface of said dichroic reflector.

15 52. The method according to claim 50, further comprising flowing a second cooling medium through a plurality of apertures in said dichroic reflector so said second cooling medium contacts the exterior surface of said ultraviolet light emitting device.

53. The method according to claim 50, further comprising flowing a second cooling medium through a third space defined between said dichroic reflector and said ultraviolet light emitting device.

20 54. The method according to claim 50, further comprising reflecting at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device off of said dichroic reflector such that said some ultraviolet radiation

contacts the surface of the article to be cured prior to said article entering said tubular ultraviolet light emitting device.

55. The apparatus according to claim 50, further comprising reflecting at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device off of said dichroic reflector such that said some ultraviolet radiation contacts the surface of the article to be cured after said article exits said tubular ultraviolet light emitting device.

10 56. The apparatus according to claim 50, further comprising reflecting at least some ultraviolet radiation emitted from the exterior surface of said tubular ultraviolet light emitting device off of said dichroic reflector such that said some ultraviolet radiation contacts the surface of the article to be cured prior to said article entering said tubular ultraviolet light emitting device and after said article exits said tubular ultraviolet light emitting device.